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Evaluation of a Tool for Producing and Presenting Interactive Videodisc Job Aids

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Hyperlinks provide rapid access to databases that contain all forms of media, including motion video. The use of hypermedia to present job task procedural training is widely perceived to be an efficient means of presentation. A prototype video-based workstation was developed and used to explore videodisc job aid development and use issues. Job aids for torpedo and Ellison door maintenance tasks were developed and presented on the workstation. Development issues are discussed and the results of the use of the two task aids are presented. Alternatives to the hypermedia software used in this experiment are explored.

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Foreword

This research was sponsored by the Office of the Chief of Naval Research (Code 461) and funded as part of the Exploratory Development Task entitled Videographic Interface Technology within the Office of Naval Research Program Element 0602233N, under the Training Technology Work Unit 0602233N.RM33T23.03.

The purpose of this effort was to evaluate the use of technology in developing and using a video-based job aid. The Engineering Library Visual Information System (ELVIS) used in this effort was developed by Intelligent Systems Design, Inc., under a Small Business Innovation Research (SBIR) contract with the Naval Surface Warfare Center (NSWC).

Evaluations of video-based job aids were conducted at the Naval Undersea Warfare Center (NUWC) and the Damage Control (DC) School, Fleet Training Center, San Diego.

The results of this study are intended for use in all Department of Defense sponsored training communities and depot level repair facilities.

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Summary

Introduction

Early in the development of television, the medium was recognized as a useful educational tool. Although early educational television had a number of limitations, computer technology has allowed television to be integrated with a number of other media during individual presentations. Multimedia training allowed the user to access information from still and motion video, audio, graphics, and text and aided learners in linking their knowledge between different skills. This combination of technology provided realistic, interactive training, and job aids to individuals. Technology has not proven sufficient for many training development efforts. One instructional aid, hypermedia provides rapid and convenient access to all multimedia links. Hypermedia, like other instructional techniques, depend on convenient, clear developer and user interfaces.

This confluence of domains lead to the development of a Navy-sponsored video-based workstation, known as the Engineering Library Visual Information System (ELVIS). A prototype video development, cataloging, and delivery system was developed and used to explore multimedia development and implementation issues. ELVIS is intended for use in training procedural tasks that do not require developing extensive learning strategies to guide the user. To meet this goal, ELVIS uses hyperlinks to present combinations of video, text, and graphic media.

Objective

The objective of this effort was to evaluate ELVIS, a development tool for producing and presenting videodisc job aids. The study (1) assessed the ability of novices in videodisc technology to develop videodisc job aids using ELVIS and (2) evaluated the on-the-job and classroom effectiveness of these aids.

Approach

A prototype video development and delivery workstation was developed under a Small Business Innovation Research program contract. This effort called for Navy schoolhouse and job site development of video-based instruction by personnel without extensive training in video production skills. The goal was to develop job performance aids that could be easily accessed by instructors, students, or technicians.

The ELVIS workstation is based on a Macintosh platform and uses a write-once, read-many (WORM) optical disc recorder to capture video. A separate playback-only device was used to present video.

Software to produce (author) and present the hypermedia job aid was constructed. The student could browse through a job aid which provided access to text, graphics, audio, and video. Evaluations of the hypermedia job aids were conducted at the Naval Undersea Warfare Center (NUWC) and the Damage Control (DC) School, Fleet Training Center, San Diego.

Evaluation at NUWC consisted of observing: (1) an in-house engineer without prior video-development experience develop a multimedia job aid for performing a Mark 50 torpedo procedural task and (2) an NUWC engineer and an NUWC shop floor technician use the multimedia job aid to learn to perform the procedural task.

At the DC school, a detailed multimedia job aid was developed for performing maintenance on the "Ellison" door. Student performance of the Ellison door overhaul procedure with and without the job aid was evaluated.

Results

A NUWC engineer encountered a number of problems while constructing a rudimentary ELVIS job aid. Both NUWC subjects had difficulty performing the procedure because of inadequate instructional video development and the subjects' inexperience in using the hypermedia interface.

DC school student performance of the Ellison door overhaul procedure did not differ significantly using the ELVIS job aid than it did without using it.

Discussion and Conclusions

ELVIS provides a hypermedia template that allows an author to construct a job aid by adding data. This simple procedure may lull the developer into eliminating the requirement for following basic instructional development procedures prior to adding data. The instructors and engineers observed were reluctant to invest sufficient time for adequate systematic instructional development, including video production or job aid content. For example, in-house video development is perceived as a relatively trivial task, but usually requires specialized skills. In fact, present Navy policy prevents local video development in most cases, and would have to change. Even with present video and hypermedia technology, developing and revising job performance libraries is a time consuming task.

The Macintosh interface was not sufficiently intuitive for most of the subjects. They were not able to interact with the software without coaching. DC instructors also had trouble using the interface, even after moderate practice. Further changes in technology and hypermedia interfaces are needed, even for novice development and use of job performance libraries.

Future Efforts

1. Creators and users of multimedia job performance aids should provide resources, such as a software program to introduce the mouse interface that students should be required to use, to guide the user in initially accessing media.

2. Video-based job performance aids developed for use in Navy settings should have an in-house change advocate to ensure adequate development and use of the aid.

3. The constantly changing needs of Navy training and task performance require timely modification of all media used in job aids. Local Navy training and work communities should develop in-house skills to allow continual updates to computer media.

4. Industry standards that allow software and platform portability should be monitored to ensure their incorporation into future hypermedia job aid development.

Contents

Introduction

Problem

Educational and commercial television influence us in many ways. Video images are available to most people through broadcasts to their home; through videotape rentals; through group presentations at schools, workplaces, and recreational settings; and in individualized presentations for pleasure and instruction. These forms of video provide a visual message that can be manipulated to direct attention, to speed up or slow down action, to view hazardous operations, to standardize and disseminate instruction, and to hold viewers' attention. Broadcast television combines many of these desirable instructional attributes at a reasonable cost. Some attributes were realized early in the history of television development. Closed-circuit television was first used to deliver educational programs in the early 1930s. The first educational television broadcast was presented in 1953 at the University of Houston (Texas Higher Education Coordinating Board, 1986).

Educational television is subject to the same constraints as any other presentation having instructional goals, as well as to issues inherent in televised presentations. Kozma (1986) lists a number of variables that impact on the effectiveness of television including pacing, cuing, and modeling. Cuing and modeling can be addressed in standard linear television programming. However, providing appropriate pacing for a wide range of television viewers is more difficult. This problem was addressed successfully by the advent of computer technology to control delivery of all media, including video on an individual basis.

Multimedia presentations are computer controlled systems that allow the user to access information from still and motion video, audio, graphics, and text. Early attempts to display video on a computer monitor presented numerous challenges. Videotape was used to present motion visual images, but random access was cumbersome and not reliable. However, a computer provides reliable random access to video encoded on an optical disc medium. Students can easily interact with all parts of the training. This combination of computer and videodisc technologies can be used to provide realistic, interactive training and job aids to students. An instructor can also interact with the computer controlling multimedia presentations to tailor the instruction to specific classroom needs.

Multimedia instruction may not be appropriate if the presentation is difficult to create or students cannot easily negotiate through the lesson. Other technology is needed to ease development and use of multimedia presentations. The idea of linking textual chunks in some meaningful way is usually credited to Vannevar Bush (1945), who proposed to mechanize the storage and retrieval of scientific literature. Until the advent of computer and optical disc storage, there was no easy way to implement his proposal for nonlinear or hypertext. Hypermedia extends this idea to all forms of media. The concept of hypermedia is rapid and convenient access to extensive informational databases that may take the form of text, graphics, video, and audio. Links are easily created between objects in the databases. Although hypermedia development has been extensively explored, hypermedia systems still depend on convenient and clear developer and user interfaces, which in many cases are lacking.

While computer-based interactive multimedia presentations expand the potential for procedural training and job aids, they also pose a number of questions that have not been fully explored. These include providing the correct mix of media, making the mix easily accessible to students, and finding ways to develop affordable multimedia training.

Objective

The objective of this effort was to evaluate ELVIS, a development tool for producing and presenting videodisc job aids. The study (1) assessed the ability of novices in videodisc technology to develop videodisc job aids using ELVIS and (2) evaluated the on-the-job and classroom effectiveness of these aids.

Background

While the effectiveness of instructional television broadcast to targeted audiences has produced some inconclusive findings (Silvernail & Johnson, 1990), most studies show television to be as effective as traditional classroom presentations (Whittington, 1987). However, most television presentations do not allow the student to interact with the instructional content for review and testing. By controlling the pacing of presentations, television is viewed by some as a different medium from interactive videodisc instruction, where the student controls the pacing (Kozma, 1986).

Many educators believe that interactive videodisc instruction (student control of pacing and review) has unique educational capabilities (Beautement, 1991; Hannafin, 1985). To fully exploit these capabilities, several basic educational features must be incorporated such as orientation toward and sequencing of training materials (Hannafin & Phillips, 1987). Unfortunately, many of the studies investigating interactive videodisc instruction do not provide sufficient information about the use of these features to assess their effects on achievement (Fletcher, 1990; McNeill & Nelson, 1991).

Fletcher (1990) used meta-analysis techniques to analyze 28 studies that compare interactive videodisc instruction with conventional instruction in military, industrial, and college settings. In studies that report training time, Fletcher found a modest increase in performance and a 31% reduction in training time. However, the interactiveness of this training medium may lead students to increase time on task.

Cennamo, Savenye, and Smith (1991) found the amount of time students needed to complete a lesson differed significantly between three treatment groups. A technical science lesson was presented via linear television, instructional television, or interactive video. Students watched the linear presentation passively, while instructional television and interactive video required them to respond to questions. Students viewing the interactive presentation could view feedback as long as they desired, whereas the instructional television presentation was group-paced and presented the same feedback for a fixed time. The mean time students needed to complete the interactive video lesson was 25.3 minutes, the instructional television lesson was 23.2, and the linear television lesson was 18.5 minutes. Recall scores for students who used interactive video were significantly higher than for those who watched linear television, but there was no difference between the scores of students who used the interactive video and those who used instructional television.

While interactive videodisc instruction has been shown to provide significant achievement effects (Fletcher, 1990), the development costs for this type of instruction can be high. Most studies of interactive videodisc instruction do not address the development costs faced in video production. Beautement (1991) estimates production of a single 1-hour videodisc costs $380,000 in the United Kingdom. This cost may be acceptable compared to the cost of developing highly realistic simulators, but many job training environments cannot tolerate this expense. They need an in-house capability for development of technologically advanced video presentations designed by schoolhouse personnel, and controlled by instructors, students, or on-the-job trainees.

Navy Interactive Videodisc Training Investigation

The Fleet Engineering Special Projects Office at the Naval Surface Weapons Center Detachment, White Oak Laboratory, Silver Spring, MD became interested in interactive videodisc job aids in the early 1980s with the focus on maintenance and repair of weapons systems. The initial objective was to provide a means for producing inexpensive interactive videodisc job aids and training in a depot maintenance setting. This objective eliminates professional video production while empowering schoolhouse and shop personnel to develop and produce interactive video training. A Small Business Innovation Research (SBIR)[1] contract was awarded to investigate the feasibility of using nonexperts to produce and transfer video to a microcomputer workstation and to use production tools to author job/instructional aids.

This SBIR research resulted in the development of a videodisc workstation, known as the Engineering Library Visual Information System (ELVIS). ELVIS is intended for use in training procedural tasks that do not require development of extensive learning strategies to guide the user. To meet this goal, ELVIS uses hyperlinks for presenting combinations of video, text, and graphic media. This prototype video development, cataloging, and delivery system was used in the effort reported here to explore video development and implementation issues.

Approach

Video presentations have been incorporated in a variety of Navy training programs, from traditional group-paced classroom and shipboard presentations to computer-controlled, individualized videodisc presentations in schoolhouse laboratories or at shore-based job sites. However, most video applications depend upon development efforts by professionals not at the Navy schoolhouse or job site. This effort called for in-house development of video-based instruction by personnel without training in video production skills. The ultimate goal was to develop low cost, easily modified job performance aids that provide easy-to-use procedural guides. During phase I of the SBIR effort, a prototype video workstation was developed. Phase II research refined this development and delivery workstation to include interactive videodisc.

Initial evaluation of this workstation was undertaken by the Naval Undersea Warfare Center (NUWC), Division Keyport, and the Navy Personnel Research and Development Center (NAVPERSRANDCEN). The NUWC evaluation consisted of an in-house engineer without video development experience developing a videodisc job aid for a Mark 50 torpedo procedural task. A NUWC engineer and a shop floor technician used this job aid to perform the task.

[1]This SBIR work was performed by Intelligent Systems Design (ISD), Inc., 16771 N. E. 80th Street, Suite 101, Redmond, WA 98052 under contract with the Naval Surface Weapons Center Detachment, a branch of the Naval Surface Warfare Center.

A second evaluation was carried out at the Damage Control (DC) School, Fleet Training Center, San Diego, where development of interactive videodisc job aids for several damage control tasks was jointly undertaken by NAVPERSRANDCEN personnel and DC instructors. Student performance was assessed following instruction with and without video job aids.

ELVIS Workstation

To provide a workstation that would be easy to use to develop and display multimedia instruction in the form of still and motion video, audio, text and graphics in an interactive setting, Patton, Staley, & Chin (undated) stated that the system should:

1. Be similar in functionality to personal computer-based, desk-top publishing (DTP) systems.

2. Be useable by technicians who have no special training in computer, video, and multimedia technologies.

3. Be able to collect, add, and update text, graphics, still and motion video, and sound data in a multimedia database.

4. Be based on the Apple Macintosh II[2] platform (to be compatible with an existing NUWC logistics system), and include video capture and processing cards, write-once optical discs to store analog video, and a large capacity hard disc drive.

5. Be capable of organizing, storing, searching, linking, and retrieving job tasks which have been attached to text, graphics, still and motion video, and sound resources.

6. Contain all the forms of media in a job task aid so that interactive information describing that job task can be accessed by new and existing operators. The job task aid will be used to test and evaluate the ease of use and the resulting quality of an interactive program authored in ELVIS.

To meet these requirements required making a number of compromises in selecting both hardware and software. Since these selections were made (in 1990 and early 1991), the technology has continued to evolve. ELVIS workstation hardware and software are described in the appendix.

ELVIS development included evaluation of several video cameras and recorders (Patton et al., undated). The criteria for evaluating this equipment were: (1) image resolution, (2) ease of use, (3) ruggedness, and (4) cost. S-VHS tape format was selected as having the best resolution for the cost. A single unit camcorder offered the best tradeoff between portability and operator fatigue. To avoid fatigue, Patton, et al. (undated) recommended that the camera operator limit taping to a few minutes at a time and use a tripod when possible. Placing a microphone on the person speaking was recommended for obtaining audio because camera mounted microphones are unsuitable for use in noisy environments. To aid inexperienced personnel, a cart with two monitors (one facing the camera operator and the other facing the on-camera speaker) was recommended.

[2]Identification of software and specific equipment is for documentation only and does not imply endorsement.

Mark 50 Torpedo Maintenance Job Performance Aid

How technology can aid a novice in video development and job aiding was addressed first. NUWC, which serves as a primary undersea weapon test, evaluation, engineering agent, and repair depot, is a highly automated facility that uses Macintosh computers to monitor and control torpedo repair logistics. Many repair tasks are complicated and are not routinely performed. Technicians performing these tasks can benefit from interactive video job aids.

Development

To understand the video development process, we observed an NUWC engineer (Engineer 1) develop a job aid. Engineer 1 was familiar with the Macintosh operating system used in ELVIS. However, she had no experience with developing a storyboard, shooting video, or other production techniques used in creating the job performance aid.

On the day prior to shooting the video, Engineer 1 developed a short procedural job aid "script" to serve as a storyboard. The script indicated which parts of the procedure would be still images and which would be action sequences. The task was to make a flow adjustment in an oxidizer (commonly called the oxystock) unit that is part of the Mark 50 torpedo propulsion unit. The script divided the task into greater detail than the description of the procedure. Using the script, Engineer 1 reviewed the procedure with the technician who would appear on camera.

Prior to video production, Engineer 1 viewed a training aid created by the developer of ELVIS (ISD, Inc.) to gain insight into the video development process This training aid provided an overview of camera operation, lighting, and production techniques.

Following this viewing, the video was produced. The technician performed and narrated the actual on-camera work. Another NUWC engineer (Engineer 2), who had previously developed an ELVIS-based job aid, assisted with video cabling and did the actual camera work, which was directed by Engineer 1. Approximately 5 minutes of videotape were produced. This unedited videotape was transferred to a write-once, read-many (WORM) disc, indexed by initial and end frames of each job sequence, and then linked to specific job structure steps. Engineer 1 transferred a previously prepared text file to the ELVIS editor to complete development of the job aid (with the help of a systems analyst from the ELVIS contractor because of software problems). At the end of the day, the job performance aid was complete. Some problems that were corrected over the next few days were noted in review. On the day following initial development, Engineer 1 was interviewed about the development process.

Trials

Two NUWC employees were randomly selected to perform the Mark 50 torpedo oxystock adjustment using the job performance aid. Neither employee was familiar with the procedure. Subject 1 was an electrical engineer who had not worked with the Mark 50 torpedo. He was familiar with the Macintosh computer, computer-based training systems in general, and had experience with video production. Subject 2 was a Mark 46 technician, who was not familiar with either the Mark 50 torpedo or the oxystock adjustment procedure and had never used a personal computer, or a home video play or record device.

Prior to the trials, Engineer 2 made some minor revisions in the job aid text. Additional changes were made in both the text and video portions of the job aid based on the observations of the first trial. Both trials were videotaped to document each subject's performance using the job aid.

Engineer 2 briefed both subjects on the purpose of the clinical trial and the task they were to perform. Since Subject 1 was familiar with the Macintosh computer, common features of the user interface such as the mouse, windows, icons, and scroll bars were explained only to Subject 2. A short orientation to the ELVIS user interface was given to both subjects. This included selecting job task steps and substeps using the ELVIS hierarchical database structure, replaying associated video information, and expanding graphic displays. The orientation was not scripted beforehand.

Ellison Door Maintenance Job Performance Aid

NAVPERSRANDCEN sought out a Navy schoolhouse site where an interactive video training aid could be used as an adjunct to classroom and laboratory instruction. The DC school was already participating in NAVPERSRANDCEN research involving classroom distance learning using remote television broadcasts. Because some tasks for the distance learning required observation of hands-on procedures, it was decided to produce a set of video job aids to enhance laboratory exercises following remote broadcasts. Six relatively short procedures were selected. NAVPERSRANDCEN provided the video equipment and expertise, while the DC school provided scripts and on-camera procedural experts. The job structures were entered into the job aid windows and linked to the videodisc to create six job performance aids. These job aids were shown in the classroom on 35-inch monitors. The instructor could rapidly display any procedure or repeat a specific sequence by selecting an ELVIS job structure. However, students could not use ELVIS in the laboratory setting.

Development

Another task was sought to provide an evaluation of job performance aid development and student and instructor interaction with ELVIS. Discussion with DC school instructors resulted in the selection of maintenance procedures for the machinery space balanced joiner door, known as the Ellison door.

Initial attempts to have the DC instructors produce the necessary video were unsuccessful. The instructors either lacked confidence in their ability to produce useable video for training or were not willing to devote the time required for producing video while maintaining normal teaching duties.

Consequently, NAVPERSRANDCEN and the DC school agreed to a joint video development effort: NAVPERSRANDCEN provided video experts while the DC school provided detailed procedural tasks that could be roughly translated into a working script. One or two DC school instructors performed the procedures, which were videotaped. NAVPERSRANDCEN personnel used professional editing equipment to produce 1 hour of motion video and stills from 4 hours of videotape. The tape was shot over a 2-day period. Verbal procedures were added to the tape by a DC school instructor reading a script. This tape was transfered to a WORM optical disc, which required no further editing. Development of the final ELVIS job performance aid took 1 month.

Evaluation

An ELVIS workstation on a movable cart was maintained in the instructors' office space and moved to the classroom or the Ellison door laboratory as needed. Instructors were briefed on the use of the system and were requested to instruct students on its operation. Instructors or students used the mouse interface to select Ellison door maintenance procedures. A seven-step procedural outline to power up the Macintosh was taped to the cart.

The Ellison door maintenance course is taught once every 2 weeks; it lasts approximately 2 days. To familiarize the instructors in operation of ELVIS and to observe student attitudes toward the job aid, instructors for the two classes in July 1992 used ELVIS in both the classroom and laboratory. In the classroom, instructors manipulated the ELVIS interface to select video sequences for student viewing. In the laboratory, students were encouraged to use the Ellison maintenance performance aids at appropriate times.

Because of limited classroom and laboratory spaces, and small class size, it was not possible to assign students from the same class randomly to ELVIS or conventional training conditions. During the next 2 months, the first class of the month was shown the ELVIS job aids in the classroom and asked to use the job aids in support of the laboratory procedures. The second class of the month was instructed in the conventional way; that is, classroom students viewed a video for civilian Ellison door installers, and used a combination of worksheet and instructor supervision in the laboratory. The class size during this period ranged from three to nine students.

Following the laboratory, students were tested on a critical component of the Ellison Model 139B door maintenance procedures: overhauling the hydraulic cylinder. The same observer monitored all the testing using a checklist to ensure reliability across students. Because of the time required for testing and the availability of only one observer, not all students were tested. The first class consisted of three students, all of whom were tested. In other classes, three students were randomly selected to represent the same levels of experience found in the first class. This resulted in a total of six students tested under each condition. Measures were collected on overhaul performance, safety, time on task, and the standard DC school written final examination.

The performance measure consisted of disassembly, inspection, and reassembly of an Ellison door hydraulic cylinder. The observer scored each step as it was completed. Four of the steps required that the student take appropriate safety precautions. Any student who did not take them was stopped and advised to do so by the observer prior to continuing. Each student was videotaped for later review to clarify any discrepancies. All students took the same 25-item multiple-choice written test at the end of the laboratory session.

Results

Mark 50 Torpedo Maintenance Job Performance Aid

Development

Engineer 1 used computers extensively on the job, and perceived herself to be a fairly knowledgeable computer user. She felt that technology had a positive impact on both her home and work situations. In general, Engineer 1 found the ELVIS interfaces straightforward, although she considered the task structure editing process poorly designed. Using a version of the software that had not been completely debugged created other problems. With the aid of Engineer 2 and a contractor's representative, a rudimentary job aid that could be used for evaluating user performance was produced. The job aid had minimum revision prior to the trials.

Trials

Subject 1 performed the majority of disassembly and reassembly steps with only one viewing of the NUWC job aid, and displayed considerable confidence during most of the steps. He watched and performed the procedure one step at a time, without previewing the entire procedure prior to performance. During the trial it became apparent that Subject 1 did not completely understand how to access some job aid steps. Engineer 2 had to intervene on several occasions to provide clarification.

Subject 1 was able to perform the majority of steps accurately with some exceptions. Because the job aid was created hurriedly and without any revision, some of its shortcomings became apparent when technicians with no knowledge of the Mark 50 torpedo attempted to use the job aid.

1. When Subject 1 reached the key step of the procedure, the actual adjustment of the flow valve, he expressed confusion over what should be done, reviewed the associated video segments several times, and displayed uncertainty as to whether he was performing the adjustment correctly.

2. At the end of the procedure, still video images replaced instances of full motion video. Initially, Subject 1 hesitated to perform steps supported only by still video images, although they were adequate for understanding the step. Subject 1 eventually performed these steps, but with less confidence than the steps supported by full motion video. This was observed in the subject's visual fixation; he continually alternated between looking at the still visual and the hardware before performing a step. During debriefing, the subject confirmed that he was confused by the sudden change in the presentation of the visual material. He indicated that he had come to rely on viewing the motion video and felt deprived when it was not provided.

Subject 2 was very uncomfortable and nervous at the start of his trial and had considerable difficulty mastering the mouse. He had difficulty correlating cursor position with movement of the mouse and was unable to move the cursor on the smaller icons and control boxes on the screen. Windows, "point and click" interface, icons, and scrolling were new to him. He appeared to be very frustrated; that is, he sat staring at the screen until the engineer provided additional instruction. Subject 2's orientation to ELVIS job structure was equally difficult. He did not grasp the concept of the hierarchical presentation of job aid text. He also had difficulty using the video remote control unit that was operated through the mouse.

Once Subject 2 felt comfortable with the mouse interface and could open the job aid windows, he proceeded with the task, but at a somewhat lower performance level than Subject 1. As Subject 2 grew more confident, he performed each step noticeably faster. He also exhibited a dramatic learning curve with the mouse and became proficient at replaying the video information. Several problems were observed, however.

1. The organization of the job procedure text in a hierarchical structure continued to confuse Subject 2; when he reached the bottom of a subtask, he needed assistance to move up the hierarchy to the next level.

2. Subject 2 did not use the auxiliary text window that displays special additional information and warnings because ELVIS provides no cue to look at the window when a new message is displayed.

3. On several occasions, when a video segment was available, he did not read the associated job aid text or use graphic displays. In many cases, the video did not provide sufficient information to perform a step, especially toward the end of the procedure when still video images were used.

Subject 2 exhibited behavior similar to that of Subject 1. He shifted his attention between the visual images on the monitor and the hardware several times before performing most steps, and exhibited the same hesitation and confusion over the key flow valve adjustment step as Subject 1. He was able to perform the adjustment only with direct intervention by the engineer. The text and visual information presented for this step were obviously inadequate for performance by a novice.

Ellison Door Maintenance Job Performance Aid

A series of one-way analyses of variance (ANOVAs) was computed for performance score, safety score, and performance time for the Ellison door hydraulic cylinder overhaul procedure; and final written test covering all course content. Table 1 presents the mean and standard deviation for each of the dependent variables; and Table 2, the results of the ANOVA for each variable.

Table 1

Performance Score Means and Standard Deviations for Students Using a Job Performance Aid (Group 1) or Conventional Instruction (Group 2)

Dependent Variable	Group	Mean	Standard Deviation
Overhaul Performance Score	1	19.2	3.3
	2	21.5	1.8
Performance Safety Score	1	3.5	0.8
	2	3.0	0.9
Performance Time (minutes)	1	16.0	1.9
	2	16.2	1.1
Final Written Test Score	1	84.0	13.1
	2	90.7	5.4

Table 2 shows there were no significant differences between the two groups on any of the measures. Table 1 shows that the group using the ELVIS job aid (Group 1) made more errors on the hydraulic cylinder overhaul and the final written test, while the group receiving conventional instruction (Group 2) made more safety errors and took slightly longer to perform the overhaul.

Table 2

Results of Analyses of Variance

Source	*df*	MS	F
Performance Within Groups	1	16.33	2.32
	10	7.03	
Safety Within Groups	1	0.75	1.00
	10	0.75	
Time Within Groups	1	0.08	0.006
	10	14.08	
Written Test Within Groups	1	133.33	1.32
	10	101.33	

Note. No significant differences were found.

Discussion

Mark 50 Torpedo Video Job Aid Development and Use

The addition of media such as still and motion video, audio, and graphics to augment traditional computer text displays is occurring rapidly. ELVIS is one example of this phenomenon. The results of the Mark 50 job performance aid exposed a number of problems associated with integrating an interactive multimedia system into Navy instruction. The same rules that apply to basic instructional development apply just as strongly to interactive multimedia job aids.

The results of the rapid development of the NUWC video job aid illustrate some of these implementation problems. The oxystock job aid was developed over 2 days and not subjected to formative evaluation prior to our observation of its use. As the trials showed, rapid development must be followed by further work to sort out the development bugs. For example, the change from full-motion video to still video and graphic images had been done to evaluate the ease of developing these media, not because it was considered the best way to portray these steps. Both subjects performed the early steps of the procedure better when viewing motion video. Studies on procedural learning using motion-based aids indicate that motion is usually beneficial when it aids in task discrimination, especially when combined with hands-on practice (Wetzel, Radtke, & Stern, 1993). However, each training situation must be evaluated separately because costs can be lowered dramatically if stills can meet training needs.

An interactive multimedia job aid can be a powerful and effective way to guide a user in performing a procedure, if the procedure has been developed into a clear presentation. When full-motion video adequately supported the procedural steps, the Mark 50 job aid virtually eliminated any ambiguity about what was to be done or how it was to be performed. However, in several instances the subjects had difficulty understanding a step because the video or graphic material was not clear or because there were breaks in continuity. These parts of the job aid assumed a prior level of knowledge on the part of the technician that would not support a novice. Although professional video presentations in terms of lighting, color, and sound quality may not be necessary, the visual information in the job aid must reflect basic principles regarding content consistency, continuity, and step size and document critical steps properly.

The two subjects are at opposite ends of the continuum representing use and understanding of basic computer functions. Subject 1 (the engineer) had prior Macintosh experience and was comfortable manipulating the mouse. In contrast, Subject 2 (the technician) displayed a total lack of confidence in his ability to use the computer and required considerable time to acclimate himself before initiating the procedure. Both subjects had trouble initially using the ELVIS hypermedia. The immediate use of a multimedia job aid by a totally naive user appears unlikely given the current popular interface technology.

Ellison Door Maintenance Job Performance Aid Development and Use

Development of the Ellison door maintenance job aid illustrates many of the problems faced when introducing new technology to a schoolhouse setting. Even though DC school instructors were interested in incorporating ELVIS hypermedia job aids into the Ellison door maintenance curriculum, the video and computer technology intimidated them. Job aid development required extensive NAVPERSRANDCEN support. Instructors were reluctant to learn proper operating procedures for the Macintosh and ELVIS software. They attempted to start ELVIS through trial and error rather than refer to the simple seven-step start up procedure taped to the ELVIS cart. Similarly, they did not follow instructions for turning ELVIS off, which caused occasional software failures.

Some of the problems were caused by the instructors' lack of computer literacy. Three of the four instructors had never used a mouse before and one had no prior computer experience. The instructors made a number of errors manipulating ELVIS media from which they needed help to recover. As with the NUWC technician, the instructor without computer experience had difficulty with the mouse.

The two instructors who participated in development of the job aid were instructors for the experimental classes. Even though they had practiced with the Macintosh and ELVIS software, they still required considerable help in accessing job aid steps. Because of their involvement in development, we hoped they would be strong advocates of the use of this technology in the classroom and laboratory. Although these instructors encouraged students to use ELVIS in the laboratory, few students took advantage of the video segments even though they were told that ELVIS would substitute for the normal workbook. The instructors were reluctant to require the students to use the ELVIS job aid.

It is not clear whether students were afraid to use the mouse interface or just wanted to finish the laboratory as soon as possible. Some students stood in front of the monitor looking at the text and video stills, but very few attempted to manipulate the mouse to get motion video, even when NAVPERSRANDCEN observers encouraged the students to access the information. Students gave a number of reasons for not using ELVIS; however, no pattern emerged that would explain their reluctance to use the job aid in the laboratory setting.

Revising a Job Performance Aid

Although ELVIS was supposed to provide convenient provisions for revising text, graphics, and motion video, this design parameter was not met. It is unlikely that a video-based job aid can be constructed without some form of formative evaluation and revision to ensure all users can perform the procedure using only the aid. Although this is particularly true when the job aid developer is a relative novice, no instructional developer is likely to make revisions if making them is perceived as an onerous or time consuming task. This problem is pandemic to the field of computer software. While software is, in most cases, described as easy to use, in many cases extensive efforts are needed by the user to gain proficiency.

Computer Orientation for the Novice

The Macintosh mouse-based interface was not sufficiently intuitive for the users, who were not able to interact with the software without coaching. Most students were not familiar with the Macintosh or any other computer system. Although students claimed they did not feel threatened by technological advances, few willingly approached ELVIS in the laboratory, and only one attempted to explore the job aid. Instructors using the ELVIS job aid appeared confused over how to perform simple functions, such as moving from lower to higher levels in the job structure hierarchy.

Some of these problems may be overcome by use of alternative interfaces. The most logical alternative is a touch screen, which novice computer users may accept more readily. However, a touch screen would require some trade-offs. Resolution of selection points may be decreased. Cost would increase and reliability may suffer. In many Navy environments, students work with fluids, solvents, and greases that may damage the touch screen.

Alternatives to ELVIS: Other Instructional Hypermedia

Computer literacy presently is not a prerequisite for DC classes or most other Navy training. While new technology is continually changing both classroom and shipboard environments, students and shipboard personnel often are not prepared to take full advantage of these technological advances. We observed many ELVIS users who were unwilling or unable to progress through a job aid. If users feel helpless, they are unlikely to continue attempting to access the job aid information, no matter how useful the information may be. Technological and human factor enhancements of current interfaces are needed to increase the probability that developers and users will use hypermedia workstation features. Several commercial products offer partial solutions to some of these problems.

One of the most promising approaches is the concept of a hypermedia environment enhanced by other software extensions and tools. While ELVIS is based on some hypermedia principles, many computer novices found the technology for implementing these principles difficult to use. Some commercial hypermedia systems offer the potential of simplified authoring, powerful search strategies of the database, and other enhancements. At this time, there are systems that operate across microcomputer platforms[3] and others that have the potential for translation across platforms.[4] Of these software programs, HyperCard has a relatively long history. HyperCard, originally developed by Apple Computer, Inc., resulted in the development of a large base of

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[3]Examples of these commercial hypermedia products are Authorware Pro (Macromedia Inc., approximate cost of $8,000) and MacroMind Director, which lacks some authoring capabilities (Macromedia Inc., approximate cost of $1,195).
[4]Examples include systems in MacIntosh format such as HyperCard (Claris Corp., approximate cost of $199) or SuperCard (Aldus Corp., approximate cost of $299) and systems in Windows format such as Guide 3.1 (Owl International, cost approximately $795) or ToolBook (Asymetrix Corp., approximate cost of $395-695).

external commands, which allows the HyperCard scripting language to be used with a wide variety of hardware components.

The ELVIS hypermedia system uses manufacturers' external commands to control the Panasonic optical drives and the Workstation Technologies video digitizer card. When authoring tools such as these external commands are available, they allow the instructional developer to integrate and exchange a wide variety of media. At this time, no standards exist for exchanging multimedia documents between programs or across platforms, although an advisory committee is developing a hypermedia format that could cross platforms. All of the current programs have proponents, and each user must evaluate them for their own needs.

The ability to access the many media elements of a hypermedia job aid rapidly is important, but other hardware and software issues must be resolved before computer system media compatibility is possible. Both Microsoft Corp. (developers of the Windows environment) and Apple Computer, Inc. (developers of the Macintosh environment) are attempting to provide media access to all microcomputer users while minimizing the need for additional hardware. ELVIS uses an analog video delivery system, with video stored on WORM optical discs. The other common option is to use CD-ROM optical media, which store compressed digitized video and other types of data. Development of CD-ROM-based job aids can be confusing because of the lack of standards and the varying software requirements to incorporate them into the video workstation environment. Just as with the analog optical disc used by ELVIS, different CD-ROM drives and controllers require different versions of device driver software and compatible computer peripheral hardware.

The microcomputer industry is moving toward digital video, which allows the video data stream to be compressed for storage. A number of compression schemes are presently available. Whether Microsoft's Video for Windows or Apple's QuickTime becomes a standard is immaterial. Digital video and audio communication architectures, protocols, interfaces, and media compatabilities must all be brought into some standardization scheme that will allow media aids to be moved across platforms.

Present hypermedia systems present major challenges to construction of a job aid and information retrieval by novices. Simplified development of a large, well-edited video database, simplified authoring, and easy retrieval of the many media elements that constitute the databases are needed. For example, the ELVIS library for visual data cataloging uses a commercial database manager which the user must master. There is no provision to transfer cataloged data automatically into the hypermedia program. Both IBM and Apple computers are attempting to provide a "video production studio" (Donovan, 1991). Whether these extended capabilities will allow multimedia job aid development by novices remains to be seen.

Conclusion

To create, modify, and present a visual job aid is difficult and requires a dedicated staff willing to untangle the web of interrelated tasks in constructing a hypermedia job aid system. Once constructed, users face many challenges in browsing and seeking specific job information. Extensive efforts, currently underway by many major manufacturers of both hardware and software, are needed for the success of hypermedia in a microcomputer environment. Whether relative novices will be able to operate the equipment needed to develop this form of training and job aiding still is uncertain.

Future Efforts

1. Creators and users of multimedia job performance aids should provide resources, such as a software program to introduce the mouse interface that students should be required to use, to guide the user in initially accessing media.

2. Video-based job performance aids developed for use in Navy settings should have an in-house change advocate to ensure adequate development and use of the aid.

3. The constantly changing needs of Navy training and task performance require timely modification of all media used in job aids. Local Navy training and work communities should develop in-house skills to allow continual updates to computer media.

4. Industry standards that allow software and platform portability should be monitored to ensure their incorporation into future hypermedia job aid development.

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Appendix

Engineering Library Visual Information System (ELVIS) Workstation

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The Engineering Library Visual Information System (ELVIS) was based on a Macintosh IIfx microcomputer with 8 megabyte of random access memory and a 300-megabyte internal hard disk. For digital video display, a WorkStation Technologies, Inc. Moonraker card produced 30 frames per second of 16-bit color video on the display monitor in a 640 x 480 pixel window. To control the optical disc player from the Macintosh, a Hurdler II HDS/HQS extended serial board from Creative Solutions, Inc. was used. The optical disc machines consisted of one Panasonic TQ-3031F Write Once, Read Many (WORM) recorder/player and one TQ-3032F player. For display, a 19-inch Radius color monitor with Radius DirectColor/16 video board was used at Navy Personnel Research and Development Center (NAVPERSRANDCEN), which Naval Undersea Warfare Center (NUWC) upgraded to a 24-bit color display and video card. Sound was provided by a small pair of self- powered speakers.

Hardware costs for the ELVIS used in this effort totaled approximately $37,500. This included both the WORM TQ-3031F optical disc recorder and separate TQ-3032F playback-only device. A student station with a less powerful microcomputer and a play-only optical disc device would cost approximately $20,000. Each WORM optical disc costs approximately $300. These costs excluded the cost of video production hardware such as cameras, recorders, and signal stabilizers.

Authoring and Delivery Software

A software "Manager" was developed to author, organize, access, and deliver job procedural aids. The Manager controls several job aid functions including:

1. Constructing and indexing a job structure.
2. Indexing video job structure steps.
3. Entering text and graphics.
4. Linking job structure text to video and graphics.
5. Revising text, video, and graphic files.

Thus, the Manager provides the author with the ability to construct new job structures with media links, and modify existing job structures by changing text, video, and graphics and their links.

Three main user interface windows include:

1. A set of hierarchical windows to present the job procedural aid or job structure.
2. A video/graphics window.
3. A "help" window for additional explanatory text.

The author selects the appropriate window position and size for each learning experience. The job aid window displays job structure text. Text can be entered either at the prompt or imported from a generic word processor, TeachText, which is packaged with all Apple Macintosh system programs. Each text line in this window acts as a "command line." By positioning the mouse over any of these lines any combination of the following three events can occur, depending on the authoring links created: (1) opening of a lower level job structure window, (2) display of a video clip or graphic, and (3) display of text in the help window.

The job structure windows display successively more detailed job structure and can be labeled to represent the level of detail. For example, if four levels of windows are required, they might be labeled module, task, subtask, and steps.

The video window can display full motion, still video, or graphics. This display is linked to the job structure window so that media are automatically presented when a selection is made in the job structure window. Whenever video is displayed, another window provides a software-based remote control. By positioning the mouse cursor over the remote control function desired, the optical disc could be activated independently of normal ELVIS links within the preselected video segment. Normal or speeded (up to 10 times normal speed) video are available. In addition, stereo audio and an on-screen frame counter can be turned on and off. The remote control proved to be a valuable tool for authoring. Only one optical disc software driver is provided, which effectively limits ELVIS to the Panasonic drives.

The help window is an auxiliary text window that can be used for any additional information such as to explain specific Macintosh commands. Students not having sufficient time to familiarize themselves with the system can refer to this window for help. TeachText is required for entering text in this window.

The author also has two special, normally hidden windows for customizing the presentation. The "user preferences" window allows the author to specify the number of hierarchical job structure windows, their titles, and video window titles.

The "information packet" window allows specification of video, graphics, audio and text links. The video information subset requires the author to select start/stop frames and other information such as a wait state for user input before displaying video.

The basic authoring procedure, after completion of all instructional development consists of the following steps:

1. Catalog video and audio.
2. Specify number and titles of windows.
3. Enter text in appropriate window.
4. Incorporate graphics, if required.
5. Link text, graphics, audio, and video.

Following these steps automatically creates hyperlinks between all the media elements.

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